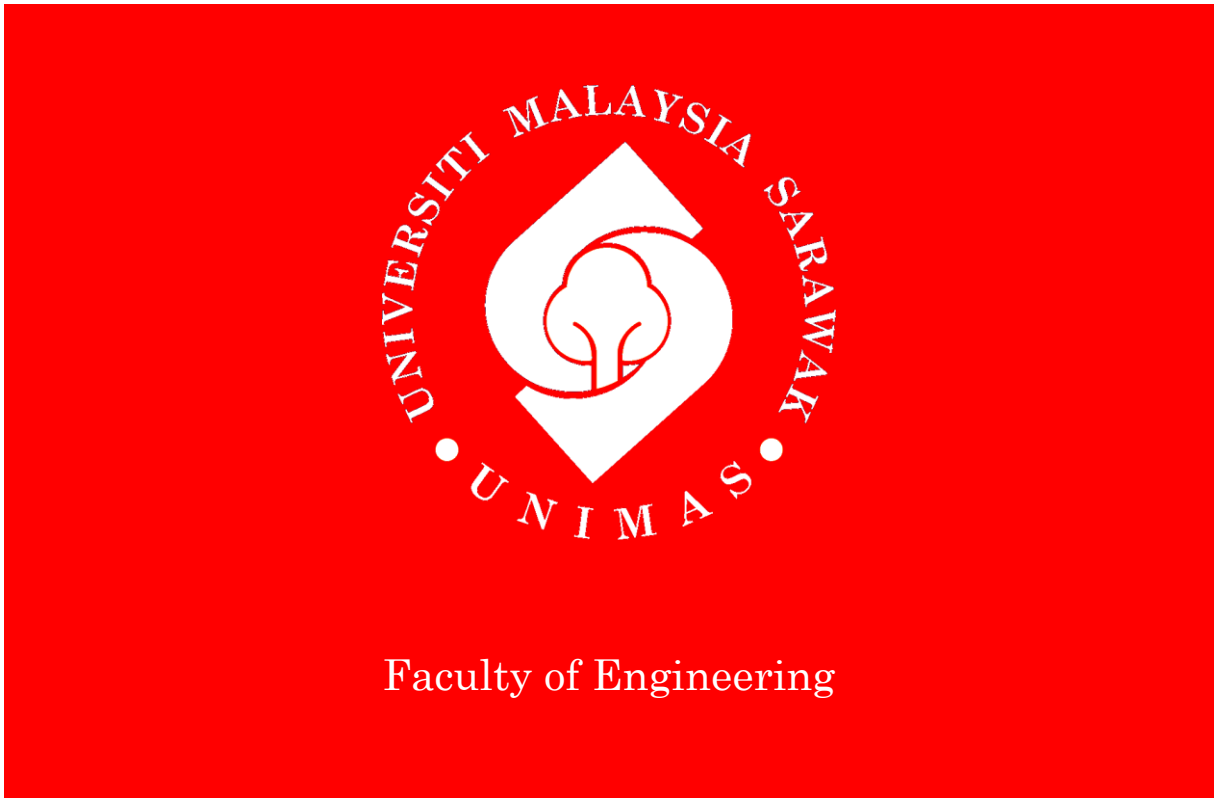

GALVANIZED IRON, AN ALTERNATIVE FOR COPPER AS EARTHING ELECTRODE AND JOINT CABLE

Nur Liyana Binti Mohd Hassan

Bachelor of Engineering (Hons)

Electrical and Electronics Engineering

2018

UNIVERSITI MALAYSIA SARAWAK

Grade: _____

Please tick (√)

Final Year Project Report [/]

Masters [ ]

PhD [ ]

DECLARATION OF ORIGINAL WORK

This declaration is made on the ....13.....day of...JUNE.....2018.

Student's Declaration:

I NUR LIYANA BINTI MOHD HASSAN, 45889, FACULTY OF ENGINEERING

(PLEASE INDICATE STUDENT'S NAME, MATRIC NO. AND FACULTY) hereby declare that the work entitled GALVANIZED IRON, AN ALTERNATIVE FOR COPPER AS EARTHING ELECTRODE AND JOINT CABLE is my original work. I have not copied from any other students' work or from any other sources except where due reference or acknowledgement is made explicitly in the text. nor has any part been written for me by another person.

13/06/2018
Date submitted

NUR LIYANA BINTI MOHD HASSAN (45889)
Name of the student (Matric No.)

Supervisor's Declaration:

I-SHIRLEY ANAK RUFUS (SUPERVISOR'S NAME) hereby certifies that the work entitled GALVANIZED IRON, AN ALTERNATIVE FOR COPPER AS EARTHING ELECTRODE AND JOINT CABLE (TITLE) was prepared by the above named student, and was submitted to the "FACULTY" as a * partial/~~full~~ fulfillment for the conferment of BACHELOR OF ENGINEERING (HONS) ELECTRICAL AND ELECTRONICS ENGINEERING (PLEASE INDICATE THE DEGREE), and the aforementioned work, to the best of my knowledge, is the said student's work.

Received for examination by: SHIRLEY ANAK RUFUS Date: 13/06/2018
(Name of the supervisor)

I declare that Project/Thesis is classified as (Please tick (√)):

☐ **CONFIDENTIAL** (Contains confidential information under the Official Secret Act 1972)*
☐ **RESTRICTED** (Contains restricted information as specified by the organisation where research was done)*
☑ **OPEN ACCESS**

Validation of Project/Thesis

I therefore duly affirmed with free consent and willingness declare that this said Project/Thesis shall be placed officially in the Centre for Academic Information Services with the abiding interest and rights as follows:

- This Project/Thesis is the sole legal property of Universiti Malaysia Sarawak (UNIMAS).
- The Centre for Academic Information Services has the lawful right to make copies for the purpose of academic and research only and not for other purpose.
- The Centre for Academic Information Services has the lawful right to digitalise the content for the Local Content Database.
- The Centre for Academic Information Services has the lawful right to make copies of the Project/Thesis for academic exchange between Higher Learning Institute.
- No dispute or any claim shall arise from the student itself neither third party on this Project/Thesis once it becomes the sole property of UNIMAS.
- This Project/Thesis or any material, data and information related to it shall not be distributed, published or disclosed to any party by the student except with UNIMAS permission.

Student signature _____ (Date) 13/06/2018

Supervisor signature: _____ (Date) 13/06/2018

Current Address:
LOT 2056, JALAN PAYA MENGKUANG, 81560, GELANG PATAH, JOHOR

Notes: * If the Project/Thesis is **CONFIDENTIAL** or **RESTRICTED**. please attach together as annexure a letter from the organisation with the period and reasons of confidentiality and restriction.

[The instrument is duly prepared by The Centre for Academic Information Services]

GALVANIZED IRON, AN ALTERNATIVE FOR COPPER AS EARTHING ELECTRODE AND JOINT CABLE

NUR LIYANA BINTI MOHD HASSAN

A dissertation submitted in partial fulfilment

of the requirement for the degree of

Bachelor of Engineering (Hons.)

Electrical and Electronics Engineering

Faculty of Engineering

Universiti Malaysia Sarawak

2018

Dedicated to my beloved parents, Mohd Hassan bin Ismail and Rosidah binti Anuar.

For their endless love, support and motivations.

ACKNOWLEDGEMENT

First of all, I would like to express my deepest gratitude to my supervisor, Madam Shirley Anak Rufus for her consistency, passion and encouragement throughout these two semesters in providing guidance for me to coordinate this project.

Next, I would like to extend my gratitude to my parents and my family members, En. Mohd Hassan bin Ismail and Pn. Rosidah binti Anuar for their endless support in terms of financial and moral. Without their existence, this project would never be accomplished.

I would also like to acknowledge the contribution of my dearest friends, Karthikgesh a/l Panir Chelvan, Christiensen Kuddy, Fara Amira binti Jamalruhanordin, Nazirah binti Abdul Hamid, Christy Emylia Asy and Norhaslinda binti Muaidi. Lastly, my appreciation goes to all those who are involved directly or indirectly in this project.

ABSTRACT

Earthing and bonding systems are essential in ensuring the safety of equipment and people. Earthing is connecting conductor from an equipment to the ground to allow high fault current to flow while bonding is a practice of joining ground conductor to minimize the voltage difference. Copper is a well-known metal for its high conductivity of current, thus, copper is widely used as earthing electrode. However, since the price of copper is quite high, copper is vulnerable to be stolen by thief. This project will analyze the performance between two conductors which are copper and galvanized iron as earthing electrode and joint cable. The main purpose of this project is to observe the potential of galvanized iron to replace copper as earthing electrode and joint cable. This project will observe the performance of these two conductors in single installation and parallel installation of earthing system. The length and diameter of these conductors will be the same and this project will be held on weather, temperature and soil characteristics. The data monitoring will be observed for eleven weeks and the result will be plotted in form of graph by using MATLAB software.

ABSTRAK

Pembumian dan pengikatan adalah penting untuk memastikan keselamatan peralatan dan orang ramai. Pembumian ialah amalan menghubungkan konduktor dari peralatan elektrik ke tanah untuk membolehkan pengaliran arus yang tinggi manakala ikatan adalah amalan menggabungkan konduktor tanah untuk meminimumkan perbezaan voltan. Tembaga adalah logam yang terkenal kerana kekonduksian arus yang tinggi, oleh itu, tembaga digunakan secara meluas sebagai elektrod pembumian. Walau bagaimanapun, harga tembaga yang mahal menyebabkan tembaga terdedah kepada aktiviti pencurian. Projek ini akan menganalisis prestasi antara dua konduktor yang berbeza iaitu tembaga dan besi bergalvani sebagai elektrod bumi dan kabel bersama. Tujuan utama projek ini adalah untuk melihat potensi besi bergalvani untuk menggantikan tembaga sebagai elektrod bumi dan kabel bersama. Projek ini akan memerhatikan prestasi dua konduktor ini dalam pemasangan tunggal dan pemasangan selari. Panjang dan diameter konduktor ini adalah sama dan projek ini akan dijalankan pada cuaca, suhu dan struktur tanah yang sama. Pemantauan data akan dilakukan selama sebelas minggu dan hasilnya dianalisis dalam bentuk graf menggunakan perisian MATLAB.

TABLE OF CONTENTS

LIST OF FIGURES

LIST OF TABLES

LIST OF SYMBOLS

Ω-m	-	Ohm-meter
Ω	-	Ohm
m	-	meter
cm	-	centimeter
mm	-	millimeter
^{O}C	-	Degree Celsius

LIST OF ABBREVIATIONS

Cu	-	Copper
EAF	-	Earth Additive Filler
EPR	-	Earth Potential Rise
GI	-	Galvanized iron
GPR	-	Ground Potential Rise
IEC	-	International Electrotechnical Commission
IEEE	-	Institute of Electrical and Electronics Engineer
NEC	-	National Electrical Code
SEB	-	Sarawak Energy Berhad

CHAPTER 1

INTRODUCTION

1.1 Introduction

This chapter explains the background study of the project, the problem statement and the proposed solution. The objectives and scope of the project are also included in this chapter.

1.2 Background Study

Earthing and bonding is a part of power system protection. In other words, earthing is also known as grounding. Earthing refers to a low impedance path to the ground created for accumulated static charges and surges due to an atmospheric or electrical fault while bonding is a practice of connecting various earthing systems to ensure that there will be no potential difference between different grounding system [1]. Earthing and bonding control any electrical potential between two bodies by discharging the excess current through a conductor [2]. An earth electrode is a metal rod which contacts the ground efficiently while a joint cable is used as a connector between earth electrodes.

Earthing system is not only installed on electrical system and equipment. In fact, it is associated with lightning protection system. It is installed in building along together with a lightning protection system to channel lightning surges through the ground without affecting other electrical instruments in the building and protect people inside the building. Besides that, earthing and bonding system serve the objectives of protecting people, electrical systems and equipment from hazard and maintaining operation of the electrical system correctly [3]. High voltage system requires different earthing system

than low voltage system [4]. Generally, a transmission system is a high voltage system while distribution system is a low voltage system. However, there are some distribution systems in high voltage. Fault rate is higher at a distribution system as compared to transmission system while high voltage distribution system has higher faults cases per year. Most of the cases were ground fault.

Improper earthing and bonding will lead to electrical hazards. There are two classes of principal hazards in electricity; first is the risk of injury to people and second is the risk of fire or explosion [5]. Electric shock is an example of electrical hazards. When there is an incomplete path for current flows, current will flow at the lowest resistance path. Thus, when a person touches an equipment either with improper earthing system or bonding system, the person may have exposed to the risk of electric shock. However, the level of injuries due to electric shock is unpredictable. With a slight flow of 0.05A current through human body, the muscle contractions of the heart will become involuntary. Accordingly, the worst case of electric shock will be dead due to suffocation.

As have been noted, earthing electrodes will be buried in the ground for a long time, thus it is crucial to choose the best material to be used as earthing electrode. There are few factors need to be considered in choosing earth electrode which is conductivity of metals, mechanical strength and rate of corrosion [3]. The purpose of an earthing system is to channel high fault current to the ground, hence the metals used must have adequate current-carrying capacity in normal operations and during faults. On the other hand, the other two factors are related to soil characteristics. Earthing system is installed to the ground where the soil may have different strata. For this reason, the earth electrode needs to be able to go through the non-uniform soil without breaking apart. Equally important, the earth electrode needs to be capable to withstand soil corrosivity.

Different countries have different standard in earthing and bonding systems. However, these standards provide a good practice of earthing and bonding system to ensure the safety of people and equipment. National Electrical Code (NEC) provides standards which are used in the United States of America while in United Kingdom, the standards are International Electrotechnical Commission (IEC). Article 250.54 NEC stated that the earth electrode must be copper or any non-corrosive metal without joints or splices [6]. Copper has been used as an earthing electrode and joint cable due to its good performance in conducting large current and its ability to withstand moisture which makes copper less prone to corrosion [7], [8].

1.3 Project Motivation

The increasing number of copper theft is worrisome not only because the increasing cost to compensate the losses, but the safety of personnel is of concern. Henceforth, a potential available metal conductor is needed as an alternative to copper in earthing and bonding system. The metal conductor must be able to conduct high current yet with a reasonable price. Galvanized iron (GI) is a widely used metal in civil engineering is found to have almost the same properties as copper in terms of conductivity. A few studies have been made to observe the performance of galvanized iron as an earth electrode. Thus, this project was conducted to observe and analyze whether there are possibilities for galvanized iron to replace copper in earthing and bonding system.

1.4 Problem Statement

Copper is one of the best metals in conducting current alongside gold and platinum. Thus, copper is widely used as an earthing electrode and joint cable due to its reliability and feasibility. Besides its ability in electrical conductivity, copper is less prone to corrosion and highly permeable as compared to any other metals. On the other hand, gold and platinum are unfeasible to be used in earthing and bonding system because of their ultimate high prices.

Nevertheless, copper is also vulnerable to theft due to its high price. Thieves are more attracted to steal copper rod because they are easy to obtain from substations even though the copper rod is coated with aluminum to make it less vulnerable. Although the use of copper in both earthing and bonding system is feasible, utilities cannot adapt to the losses of copper. Up until now, there has been a lot of articles in newspapers regarding copper theft all over Sarawak. The target is not only copper in the earthing system but also copper in high voltage equipment such as a transformer. Sarawak Energy Berhad (SEB) spent million Ringgits to compensate a hundred cases of copper theft. The main concern in copper theft is the safety of personnel when doing maintenance or technical job. Besides that, the utility is obliged to invest a big amount of money to compensate the damage caused by copper theft.

As mentioned before, the main concern in copper theft is the safety of personnel. This illegal activity is not only risking the safety of the thief, but also the safety of persons in charge of the substation or equipment. Improper earthing and bonding system will lead

to electrical shock. Thus, the act of stealing copper from the substation and any electrical equipment may lead to electric shock due to the incomplete path of current flow. Furthermore, the effects of copper theft will lead to disrupting of the power supply, which causes inconvenience to the public.

A few developing countries have been replacing the use of copper to steel in the earthing system. Steel is much cheaper than copper. Furthermore, as an alloy, steel is durable and ductile. However, the use of steel in the earthing system is considered dangerous. Steel is unable to channel high current to the ground. In other words, steel has a lower conductivity of current than copper. In addition, steel is prone to corrosion. Thus, it is important to find a metal which can conduct high current at a reasonable price.

1.5 Project Problem Solution

The use of copper as earthing and bonding system is no longer reliable if copper theft cases continued to increase. Even though awareness has been given to the public regarding the danger of copper theft in terms of safety, the number of this activities does not seem to decrease. An alternative for copper is vital to ensure the public safety and at the same time improve the reliability of earthing and grounding system. An alternative metal which is galvanized iron is found to replace copper in earthing and bonding system.

Galvanized iron is widely used as a pole strengthener in a construction site. In term of money wise, galvanized iron is way cheaper than copper. Galvanized iron is said to be a good earthing electrode because it has almost the same characteristics as copper in terms of resistivity and conductivity [9]. Galvanization is the method of coating steel or iron with zinc [10]. Zinc is used as coating layer because of its characteristics of resistant to corrosion. Even though there are two options of galvanization between iron and steel, steel is less favorable to be chosen as an earthing electrode because of its low conductivity of current.

This project will study the performance of galvanized iron as an earthing electrode in the earthing system and joint cable in bonding system. The project will be conducted in a wide area at Kota Samarahan, Sarawak. Both copper and galvanized iron will be tested in single and parallel installation of earthing system. As for bonding system, the parallel connections will be joint by copper wire and galvanized iron wire. The method

used to determine earth resistance will be Fall-of-Potential method due to its ability and reliability in any type of soil [11].

1.6 Project Objectives

The aims of this project are:

1. To determine the soil characteristics in Kota Samarahan, Sarawak.
2. To analyze the potential of galvanized iron as earthing electrode to replace copper in earthing system.
3. To analyze the potential of galvanized iron as joining cable to replace copper in bonding system.

1.7 Scope of Project

The scopes of this project are as follow:

1. Determine soil characteristics in Kota Samarahan, Sarawak.
2. Measurement of earth resistance for earthing and bonding system in a single installation.
3. Measurement of earth resistance for earthing and bonding system in parallel installation with a set of:
    a. Copper rods and copper wire
    b. Copper rods and galvanized iron wire
    c. Galvanized iron rods and copper wire
    d. Galvanized iron rods and galvanized iron wire
4. Comparison of earth resistance for a different type of installation for earthing and bonding systems.
5. Comparison of earth resistance for a different type of earth electrode and joint cable in parallel connections.
6. Analyzing the lowest earth resistance between different types of earthing and bonding system.

1.8 Report Summary

Overall, this final year project report consists of five chapters. The chapters are an introduction, literature review, methodology, results and discussion and lastly conclusion and recommendations.

Chapter 1 is the introduction. This chapter briefly explains the project and its objectives. The background study and scope of the project is included in this chapter. In addition, this chapter discussed the problem statement and the proposed solution regarding the problem.

Chapter 2 covers the literature review. Past research papers and projects are studied to adapt to this project. The findings, limitations, and recommendations from past researchers are discussed in this chapter to improve the proposed project.

Chapter 3 describe the method used in this project. The materials and devices used for testing are also included in this chapter. This chapter also discussed the standard used in conducting the project.

Chapter 4 discuss the results obtained from this project. The results include comparison, analysis, and calculation of real-time data. Then, the results are discussed to observe any factors affecting the results.

Chapter 5 is the conclusion and recommendations of this project for future references. This chapter concludes all results that have been obtained. In addition, the limitations of this project is listed and future recommendations are included in this chapter.

CHAPTER 2

LITERATURE REVIEW

2.1 Introduction

This chapter discussed the main ideas of this project which are an earthing system, bonding system, and soil characteristics. In addition, this chapter includes the study of previous research regarding the main topics.

2.2 Earthing and Bonding System

According to Institute of Electrical and Electronics Engineer (IEEE) Standard 3003.2, earthing is connecting the conductive body to the earth whether intentionally or accidentally while bonding is connecting all conductive parts to achieve a low-impedance path [12]. There are two types of earthing in electrical scope. First, the type to ensure the safety of the electrical system and the other one is the type to ensure the safety of electrical equipment. The grounding of the electrical system is connecting at least one current-carrying conductor, either solidly or through an impedance to the ground. On the other hand, equipment grounding is the practice of bonding all non-current carrying conductor together to build a low-impedance path.

Similarly, earthing and bonding has the same objective; to prevent electrical hazard, but both systems uses different practice to achieve this objective. Generally, earthing and bonding is important to protect system, equipment, and personnel from electric shock. There are three fundamental of earthing [13]. First, to limit voltage surges caused by lightning or fault current. A single strike of lightning can carry up to 200 000 volts. Earthing helps to control this voltage and minimize the damage caused by lightning

surges. Secondly, earthing is important to stabilize voltage under normal operating conditions. Earth is a large earthing system where all point in the earth is assumed to be zero voltage. Therefore, by connecting an earthing electrode to the ground will help to maintain the voltage at zero volts. Lastly, the earthing system facilitates the operation of overcurrent devices during ground-fault conditions. A ground fault is an unintentional connection between an ungrounded conductor of an electrical circuit and any non-current carrying conductor. An earthing system does not clear high fault current, it only allows the fault current to flow away to the earth. Instead, an earthing system stimulates the overcurrent devices to clear the fault.

2.2.1 Earthing System

Corrosion is the main problem associated with the earthing system. Any metals buried in the soil for a period is subjected to corrosion. There are three different types of corrosion which are chemical corrosion, corrosion caused by direct current and galvanic corrosion [3]. Chemical corrosion occurs due to chemical reactions between an earthing electrode and chemical compounds of soil. Galvanic corrosion is known as dissimilar metal corrosion which occurs when two or more dissimilar metals are coupled into electrical contact with the presence of moisture [14].

There are three (3) factors that affect the resistivity of earth electrode which are soil resistivity, type of electrodes and soil treatment [15]. Hence, choosing a suitable type of earthing electrode is important to ensure that the high fault current is able to flow smoothly into the ground. Table 2-1 summarizes different kind of conductors which are used as earthing electrode [16].